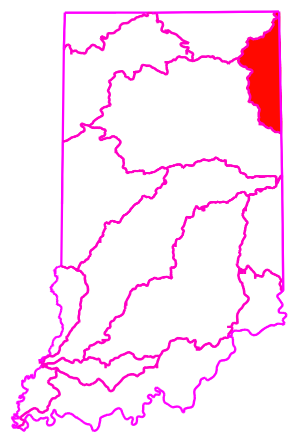


MAUMEE RIVER BASIN

By Theodore K. Greeman

General Description

The Maumee River basin in northeastern Indiana is 1,283 mi^2 and includes parts of Adams, Allen, Dekalb, Noble, and Steuben Counties (fig. 30). Principal cities within the Maumee River basin include Auburn, Decatur, Fort Wayne, Garrett and New Haven. The Maumee River begins in Fort Wayne, Ind. at the confluence of the St. Marys and St. Joseph Rivers. Most of the Maumee River basin in Indiana is drained by these two tributaries. From the confluence, the Maumee River flows 28 mi east-northeast to the Indiana-Ohio State line. The mouth of the Maumee River is in northwestern Ohio, at the southwestern end of Lake Erie. In Ohio, the Maumee River flows 108 mi to Lake Erie; thus, the total length of the Maumee River is 136 mi.

Previous Studies

Before 1960, several authors studied the hydrogeology of the Maumee River basin; however, available data were limited. Leverett (1897) reported scattered observations on ground-water availability in Indiana. Harrell, who wrote the first comprehensive report on the ground-water resources in the Maumee River basin (1935), inventoried the ground-water resources of the counties and determined the "general principles of the occurrence of ground waters in Indiana" (1935, p. 1). Stallman and Klaer (1950) described ground-water availability in Noble County and presented lithologic logs of numerous wells, as well as a potentiometric-surface map.

Enactment of laws requiring drillers to report lithologic and hydrologic properties of water wells drilled in Indiana after 1958 quickly created a new data base. Watkins and Ward (1962) reported on the ground-water resources of Adams County and included ground-water-quality information. Herring (1969) described the ground-water resources of the Indiana part of the Maumee River basin and identified principal aquifers, potential yields, and ground-water quality. Pettijohn and Davis (1973) prepared a hydrologic atlas of the water resources of the Maumee River basin in Indiana; their report includes selected information on ground-water quality and surface-water quality, water budget, surface-water flow duration, surface-water stage and discharge, and potentiometric surface. Bleuer and Moore (1972) described and correlated glacial stratigraphy in the Fort Wayne area. Bleuer and Moore (1978) continued this work by identifying and mapping unconsolidated stratigraphic units throughout Allen County. The latter report describes the stratigraphic framework of glacial deposits, ground-water availability, ground-water quality, potential for deep-well disposal, and other hydrologic factors relating to environmental issues in Allen County. Planert (1980) modeled a 700-mi^2 area in northeastern Indiana. He studied several ground-water sources and simulated several ground-water-withdrawal scenarios to evaluate ground-water-level declines and streamflow losses in northwestern Allen County.

Physiography

The Maumee River drainage basin includes three distinct physiographic units in Indiana (Malott, 1922, p. 66): the Steuben Morainal Lake Area, the

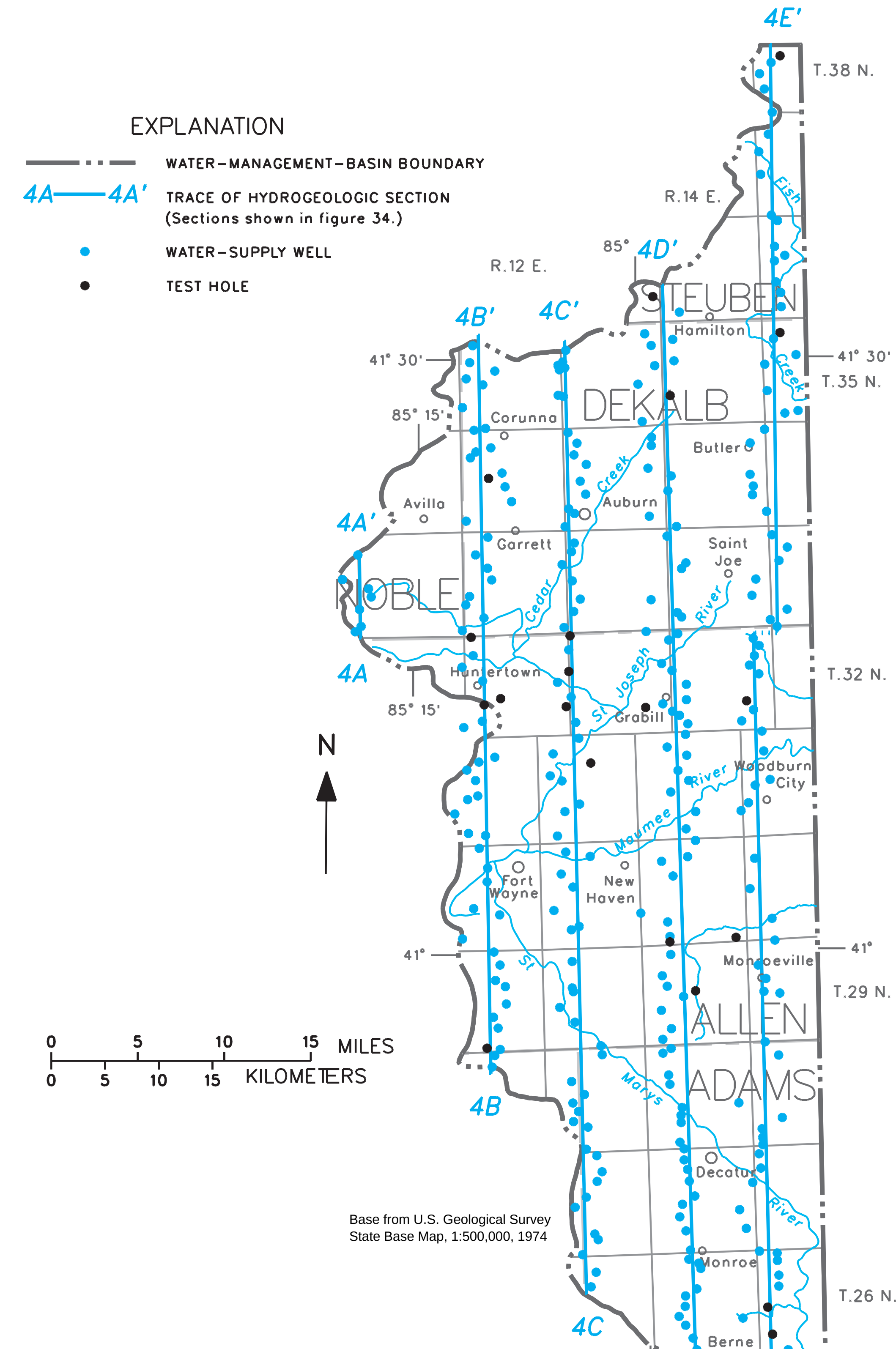


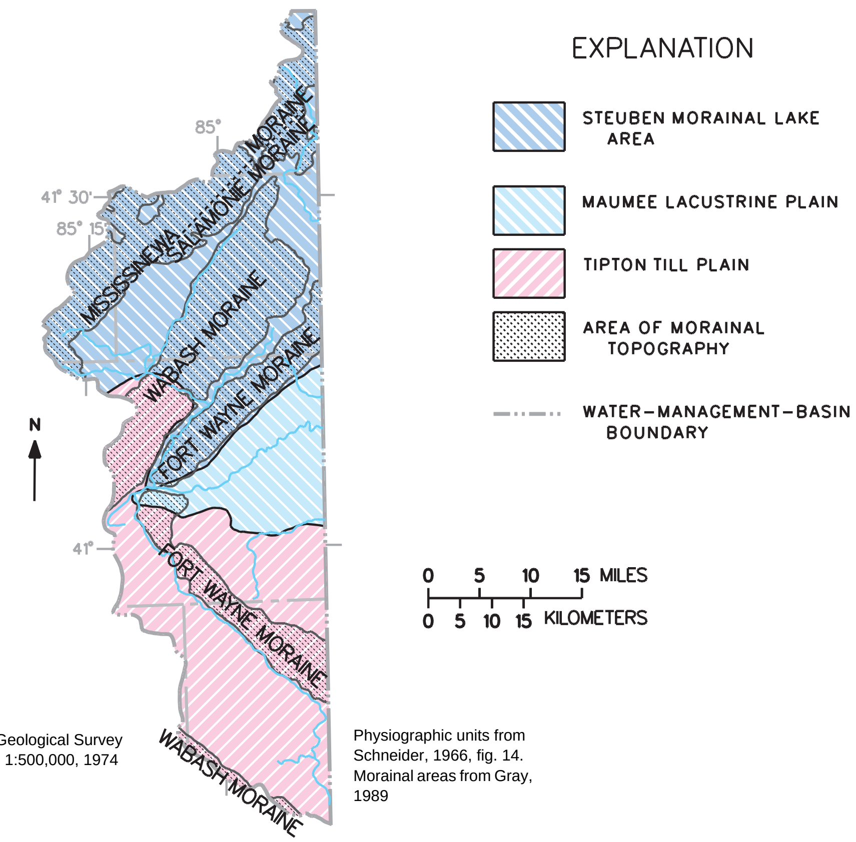
Figure 30. Location of section lines and wells plotted in the Maumee River basin.

Maumee Lacustrine Plain, and the Tipton Till Plain (fig. 2). Surface drift in the Maumee River basin was deposited between 21,000 and 14,000 years ago (Gooding, 1973, p. 24) during the latest Wisconsinan glaciation, although some alluvial deposits are post glacial.

The Steuben Morainal Lake Area (fig. 31) is an undulating region of moraines and kettle lakes, characterized by "knob and kettle" topography. "Knob" refers to the morainal hills whose local relief ranges from 100 to 200 ft. These knobs are composed of till or ice-contact sand and gravel (Schneider, 1966, p. 53). Kettle refers to the numerous surface depressions in the drift, many of which are water filled. When deposited, the moraines were composed of till mixed with sand, gravel and detached blocks of glacial ice. Kettles are depressions formed as buried ice melted and overlying sediments collapsed.

The morainal landforms (fig. 31) in the Steuben Morainal Lake Area were formed during Late Wisconsinan time, by at least two surges of the Huron-Erie Lobe and an intermediate surge of the Saginaw Lobe (fig. 8). Ice of the Huron-Erie Lobe deposited tills when it advanced into northern and central Indiana between 23,000 and 17,000 years ago (Shaver and others, 1970, p. 177). Following withdrawal of the Huron-Erie Lobe, ice of the Saginaw Lobe advanced into northeastern Indiana. A resurgence in the Huron-Erie Lobe then separated the Saginaw Lobe from its source. The resurgent Huron-Erie Lobe overran the older tills and deposited a new till on top. Deposition of this younger till was completed about 13,000 to 14,000 years ago (Wayne, 1963, p. 44). This surficial till commonly is less than 10 ft thick on northern parts of the Fort Wayne, Wabash and Salamonie Moraines (A.J. Fleming, Indiana Geological Survey, written commun., 1990).

The Maumee Lacustrine Plain, which covers more than 120 mi^2 of Indiana (fig. 31) (Malott, 1922, p. 151), is an area once occupied by glacial Lake Maumee. In this nearly level plain, lake sediments (lacustrine deposits) are incorporated



Base from U.S. Geological Survey State Base Map, 1:500,000, 1974

Physiographic units from Schneider, 1966, fig. 14. Morainal areas from Gray, 1989

Figure 31. Physiographic units and moraines in the Maumee River basin.

within the youngest Wisconsinan till deposits that cover the lake-bottom plain (A.J. Fleming, Indiana Geological Survey, oral commun., 1990). Topographic relief on the lake plain is low with slopes commonly less than 5 ft/mi. Surficial sand deposits at the perimeter of the plain are Lake Maumee strand or beach deposits. The geomorphology of the lake plain can also be interpreted as a glacially scoured lowland. The lake is possibly best characterized as a subglacial, water-filled basin that catastrophically drained its water when the ice of the Huron-Erie Lobe melted (A.J. Fleming, Indiana Geological Survey, oral commun., 1990).

Water levels in glacial Lake Maumee reached a high-stage altitude of 800 ft above sea level (Bleuer and Moore, 1978, p. 59) sometime between 14,000 and 11,800 years ago. At this stage, glacial Lake Maumee drained over the Wabash Moraine at Fort Wayne, continued to the southwest by way of the Little Wabash River (Wabash-Erie channel) (fig. 7) and joined the Wabash River at Huntington. Outflow from Lake Maumee scoured the Fort Wayne outlet to an altitude of about 750 ft.

After the glaciers retreated from the Lake Erie basin, water levels in Lake Maumee declined. The Fort Wayne outlet was abandoned as other drainage outlets opened. The Wabash Moraine became the major divide between drainage to the St. Lawrence River and the Mississippi River (Wright and Frey, 1965, p. 90). Lake Erie, the low-stage equivalent of ancient Lake Maumee, stabilized near its present pool altitude of approximately 570 ft (Department of the Army, 1989) at least 11,800 years ago (Wright and Frey, 1965, p. 90).

After Lake Erie stabilized, the lake bed was exposed to erosion. In Indiana, the Maumee River has downcut 25 to 40 ft into the glaciolacustrine sediments (Pettijohn and Davis, 1973, pl. 1) and, thus, has failed to develop a flood plain.

The Tipton Till Plain (fig. 31) is a nearly level to gently rolling, poorly drained glacial plain (Schneider, 1966, p. 49-50). The till plain is underlain by Huron-Erie Lobe tills and some stratified sediments. Resurgent periods during retreat of the last glacial ice produced the Fort Wayne and Wabash Moraines. Relief across the moraines is generally less than 50 ft, although the relief is slightly greater in several areas. These moraines range from 2 to 6 mi in width.

Surficial till composition is similar throughout the Tipton Till Plain of the Maumee River basin. Surficial tills are characterized by high clay content (50-55 percent) and low sand content (15-20 percent) (Gooding, 1973, p. 9). Glacial stratigraphy in the Tipton Till Plain is horizontally continuous and less complex than the stratigraphy of the Steuben Morainal Lake Area. Slopes are generally less than 1 ft per 100 ft.

Surface-Water Hydrology

The Maumee River and its principal tributaries drain 6,608 mi^2 of northeastern Indiana, southern Michigan, and northwestern Ohio. In Indiana, the Maumee River drains 1,283 mi^2 (Ohio Department of Natural Resources, 1985). The altitude of the Maumee River channel bottom at Fort Wayne is 728 ft above sea level, whereas at the Indiana-Ohio State line it is about 700 ft (Simpson, 1988). The average gradient of the meandering channel is 1.0 ft/mi in Indiana. This low gradient continues downstream 87 mi to Waterville, Ohio, where the Maumee River altitude is 610 ft. The gradient of the Maumee River in Indiana and northwestern Ohio is low because near-surface bedrock impedes downcutting of the channel. Between Waterville, Ohio, and Lake Erie, the Maumee River channel bottom drops 38 ft in 21 mi (a downstream gradient of 1.8 ft/mi).

Moraines divide the Maumee River basin into four subbasins that are drained by the Maumee River, the St. Marys River, the St. Joseph River, and Cedar Creek (fig. 30). The Maumee River drains a total of 2,129 mi^2 at the streamflow-gaging station at Antwerp, Ohio (7 mi downstream of the Indiana-Ohio State line). At Antwerp, the median discharge of the Maumee River (1939-85) is 631 ft^3/s, and the average runoff is 10.80 in/yr (D. V. Arvin, U.S. Geological Survey, written commun., 1991). Flatrock Creek drains 99.8 mi^2 of the Maumee River subbasin in Indiana before entering Ohio and joining the Maumee River downstream. Flatrock Creek has little or no flow at times during most dry years.

The St. Marys River begins in Ohio and flows northwest to Fort Wayne, draining a total of 840 mi^2, of which 401 mi^2 are in Indiana (Hoggatt, 1975, p. 56). The St. Marys River has a median discharge of 134 ft^3/s (as measured at a streamflow-gaging station 10.8 mi above the mouth, 1930-85), and has an average runoff of 10.32 in/yr (Arvin, 1989, p. 850).

The St. Joseph River flows southwest and drains the northern half of the Maumee River basin. Cedar Creek is the main tributary of the St. Joseph River. (Cedar Creek is 7 to 10 mi northwest of the St. Joseph River.) Cedar Creek flows parallel to the St. Joseph River through Dekalb County before turning southeast and joining the St. Joseph River in Allen County. The St. Joseph River and Cedar Creek drain a total of 1,086 mi^2, of which 843 mi^2 are in Indiana (Hoggatt, 1975, p. 56). At the streamflow-gaging station near Fort Wayne, the median discharge of the St. Joseph River (1942-55, 1984-85) is 391 ft^3/s (Arvin, 1989, p. 843); the average runoff for this period of record is 12.09 in/yr.

Several streams draining the Maumee River basin were tributary to adjacent basins during the last glacial period. Cedar Creek formerly flowed into the Eel River of the Wabash River basin near Huntertown in Allen County. As stream discharge decreased and glacial ice retreated from the area, flow over the Wabash Moraine stopped and the Maumee River basin began draining to the St. Lawrence River (Bleuer and Moore, 1978, p. 63). None of the rivers in the Maumee River basin of Indiana flow on bedrock, although alluvium thickness is less than 20 ft in several areas.

Geology

Bedrock Deposits

In northeastern Indiana, the bedrock is composed of Paleozoic limestone, dolomite, and shale that overlie Precambrian granite, basalt, arkose and other rocks (Shaver and others, 1986, pl. 2). These bedrock units have been moderately deformed by several structural elements (fig. 4).

The Cincinnati Arch is a broad bedrock anticline along the Indiana-Ohio State line. The axis of the anticline trends north-northwest from Cincinnati. In Randolph County, about 30 mi south of the Maumee River basin, the Cincinnati Arch splits. North of the split, the axis of the Cincinnati Arch trends northwest across Indiana. The axis of the other branch, the Findlay Arch, trends northeast across Ohio to Lake Erie. The Maumee River channel parallels the axis of the Findlay Arch. The entire Maumee River basin is located on the north-dipping flanks of the Cincinnati and Findlay Arches.

Bedrock in the Maumee River basin dips north into southern Michigan (Michigan Basin) at 15 to 22 ft/mi (sections 4A–4A′ to 4E–4E′, fig. 34). As the sequence of Paleozoic bedrock dips northward into the Michigan Basin, the entire sequence thickens and increasingly younger rocks are at the bedrock surface (fig. 32).

In the Maumee River basin, Precambrian rocks are buried under more than 3,000 ft of lithified sediments. About 1,000 ft of Cambrian sediments overlie the Precambrian basement in the Maumee River basin. About 2,000 ft of Ordovician sediments overlie the Cambrian sediments.

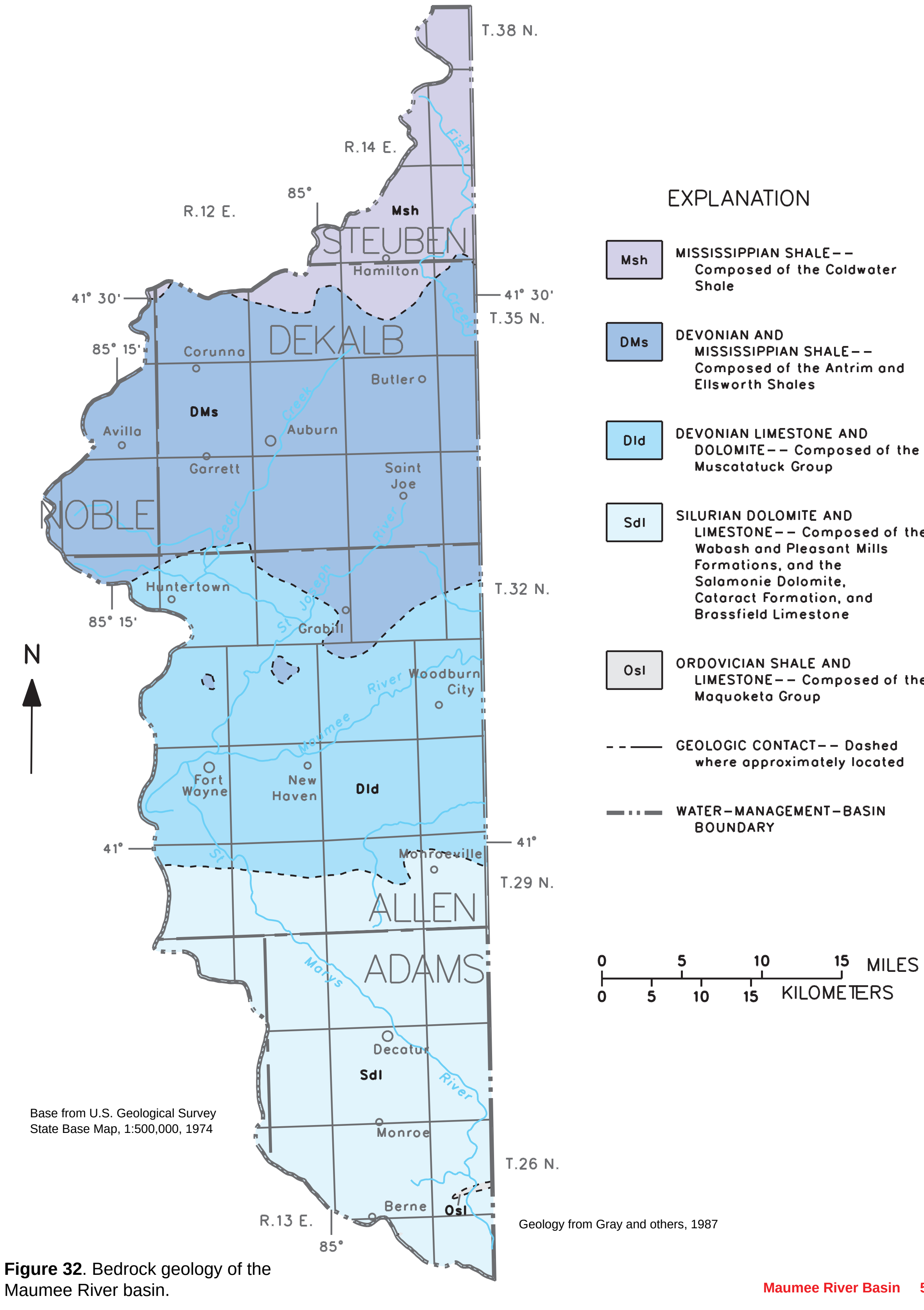


Figure 32. Bedrock geology of the Maumee River basin.

Although there are several potential aquifers in the Cambrian and Ordovician rocks, their potential as a source of potable water is doubtful. Water in these deep aquifers is highly mineralized, making the high transmissivity of the rock more desirable for waste disposal than for withdrawal of water (Bleuer and Moore, 1978, p. 48-49). The most notable of these potential disposal aquifers is the Cambrian-age Mt. Simon Sandstone. Two potential disposal aquifers within the Ordovician rocks include the Knox Dolomite and the Trenton Limestone.

Subcrops of Paleozoic bedrock underlie the drift throughout the Maumee River basin. Depth to bedrock in the Maumee River basin ranges from near zero in several areas to about 450 ft (fig. 33). The buried bedrock surface ranges in altitude from about 500 ft above sea level at the base of a deep preglacial stream channel to about 900 ft above sea level near the Indiana-Michigan State line. Rocks exposed at the bedrock surface range in age from 450 million to 355 million years (Palmer, 1983).

The oldest rocks that directly underlie the drift in northeastern Indiana are Upper Ordovician interbedded shales and limestones (fig. 32). Less than 50 ft of Upper Ordovician rock is exposed at the base of the preglacial St. Marys Bend Segment of the Lafayette Bedrock Valley (fig. 7) (Bleuer, 1989, table 1). This is the only area in the Maumee River basin where Ordovician rocks were exposed by preglacial erosion.

Overlying the Ordovician rocks throughout the Maumee River basin is a thick sequence of Paleozoic carbonate rocks. This sequence of carbonate rocks is composed of the Silurian Salina Group and the Devonian Muscatatuck Group (fig. 32). The carbonate rocks are composed of layered limestone, dolomite, and some thin shale beds. Their combined thickness attains 700 ft. The carbonate rocks are present as a subcrop below the drift south of the Maumee River. At the southern tip of the Maumee River basin, in the St. Marys Bend Segment of the Lafayette Bedrock Valley, the entire carbonate rock sequence has been eroded. The carbonate rock sequence transmits water through fractures and solution openings, and it is used as a source of ground water. A paleokarst topography preserved beneath the drift indicates that these carbonate rocks were drained by subterranean drainage. North of the Maumee River, the entire carbonate rock sequence dips below younger shales.

In Indiana and Ohio, the preglacial Lafayette Bedrock Valley (formerly Teays River Valley) drained a 35,000-mi^2 carbonate bedrock plain (L.D. Arihood, U.S. Geological Survey, oral commun., 1989). In the Maumee River basin, broad upland areas between deeply entrenched streams were underlain by 400 ft or more of carbonate rock. The entrenchment of Tertiary streams and the presence of buried karst topography indicate deep preglacial ground-water levels in the carbonate rocks. Locally, preglacial ground-water levels were near the base of the carbonate rocks.

The youngest rocks found in the Maumee River basin are Paleozoic shales (fig. 32). The Devonian Antrim Shale directly overlies the Devonian carbonate rocks. Three younger shale units overlie the Antrim Shale in the Maumee River basin: the Ellsworth Shale of Devonian and Mississippian age, and the Sunbury and Coldwater Shales of Mississippian age. North of the Maumee River a subcrop of these shales is commonly overlain by more than 200 ft of unconsolidated drift (fig. 33). Although these shales have been eroded south of the Maumee River (fig. 32), they attain a thickness of about 850 ft at the Indiana-Michigan State line. In Branch County, Mich., about 15 mi north of the Indiana-Michigan State line, shale is exposed at the land surface. These shales restrict the circulation of ground water.

Unconsolidated Deposits

During the Pleistocene Epoch, ice, thousands of feet thick, flowed repeatedly into Indiana. The Erie Lobe advanced west-southwest across northern Ohio following a carbonate-bedrock dip slope. The Huron Lobe advanced south out of the Lake Huron basin. The two lobes of glacial ice coalesced in northwestern Ohio to form the Huron-Erie Lobe. The Huron-Erie Lobe advanced up onto the Findlay and Cincinnati Arches. Some deposits from previous periods of glaciation were removed by further advances.

As the Huron-Erie Lobe moved into northeastern Indiana, it was forced to change direction by another lobe of glacial ice (fig. 8). The other lobe, known as the Saginaw Lobe, advanced into north-central Indiana from the Saginaw Bay area of Michigan. The Saginaw Lobe and the Huron-Erie Lobe abutted each other along the northwest boundary of the Maumee River basin in Indiana. This blockage forced the Huron-Erie Lobe to advance southward across eastern Indiana. The area where the two lobes of glacial ice abutted each other is underlain by thick drift. This thick drift deposit is herein called the “moraine complex.” The moraine complex has the surface characteristics of end moraines.

The St. Marys River flows near the bedrock surface along much of its course through Indiana; however, bedrock is 90 ft below the streambed 3.5 mi upstream from the confluence with the St. Joseph River (section 4B–4B′, fig. 34). Drift thickness south of the Maumee River (fig. 33) is generally from 50 to 100 ft, except where as much as 300 ft of glacial deposits fill preglacial valleys. All areas where drift thickness is less than 50 ft are south of the Maumee River. In some areas south of the Maumee River (sections 4A–4A′ to 4E–4E′, fig. 34), a rubble layer composed of silt, fine sand, and broken dolomite overlies the bedrock. Where present, this rubble layer is generally less than 5 ft thick.

Tills are exposed at land surface over most of the Maumee River basin in Indiana. Nearly all of the till is from the Lagro Formation of Wisconsinan age (Gray, 1989). The Lagro Formation was deposited by the Huron-Erie Lobe more than 13,000 years ago (Wayne, 1963, p. 44). Along the northwestern boundary of the Maumee River basin, surface deposits are a mix of Huron-Erie Lobe and Saginaw Lobe associations, especially near Huntertown in Noble County (A.J. Fleming, Indiana Geological Survey, written commun., 1990).

Glacial drift south of the Maumee River contains at least two identifiable till units, the Lagro and the Trafalgar Formations (Bleuer and Moore, 1978, p. 11). The upper unit, the Lagro Formation was deposited over lake sediments during the last glacial advance into the area. The Lagro Formation contains 10 to 20 percent sand and 40 to 50 percent clay. The base of the Lagro Formation is characteristically rich in clay because of the incorporation of the lake sediments.

The lower till unit, known as the Trafalgar Formation, is also of Late Wisconsinan age. The Trafalgar Formation contains 35 to 45 percent sand, and 15 to 20 percent clay (Bleuer and Moore, 1978, p. 11). Typically the Trafalgar Formation is extremely hard. Dense, silty sand and gravel is locally present between these till units. In most areas, this sand and gravel is too silty to be used as an aquifer; locally however, it forms small channels of coarse, shaly gravel that are tapped by domestic wells. Where coarse, this intertill sand and gravel unit is composed of 50 to 90 percent shale clasts. (A.J. Fleming, Indiana Geological Survey, written commun., 1990).

North of the Maumee River, intertill sand and gravel deposits are abundant throughout the drift. These sand and gravel deposits were concentrated into layers by meltwater that transported the silt and clay away. Some intertill deposits form laterally continuous horizons, whereas others are discontinuous. Layered intertill deposits were formed by repeated advances and retreats of glacial ice during the Pleistocene. These horizontally continuous sand and gravel deposits are disrupted in many areas. Collapse of sediments into voids left by buried ice, and lateral movement of sediments resulting from postdepositional ice advances, have produced complex deposits.

Surficial sand and gravel deposits are uncommon in the Maumee River basin of Indiana. They can be found as valley-train deposits along the St. Joseph and St. Marys Rivers, Cedar Creek, and the Fort Wayne outlet of ancient Lake Maumee. A

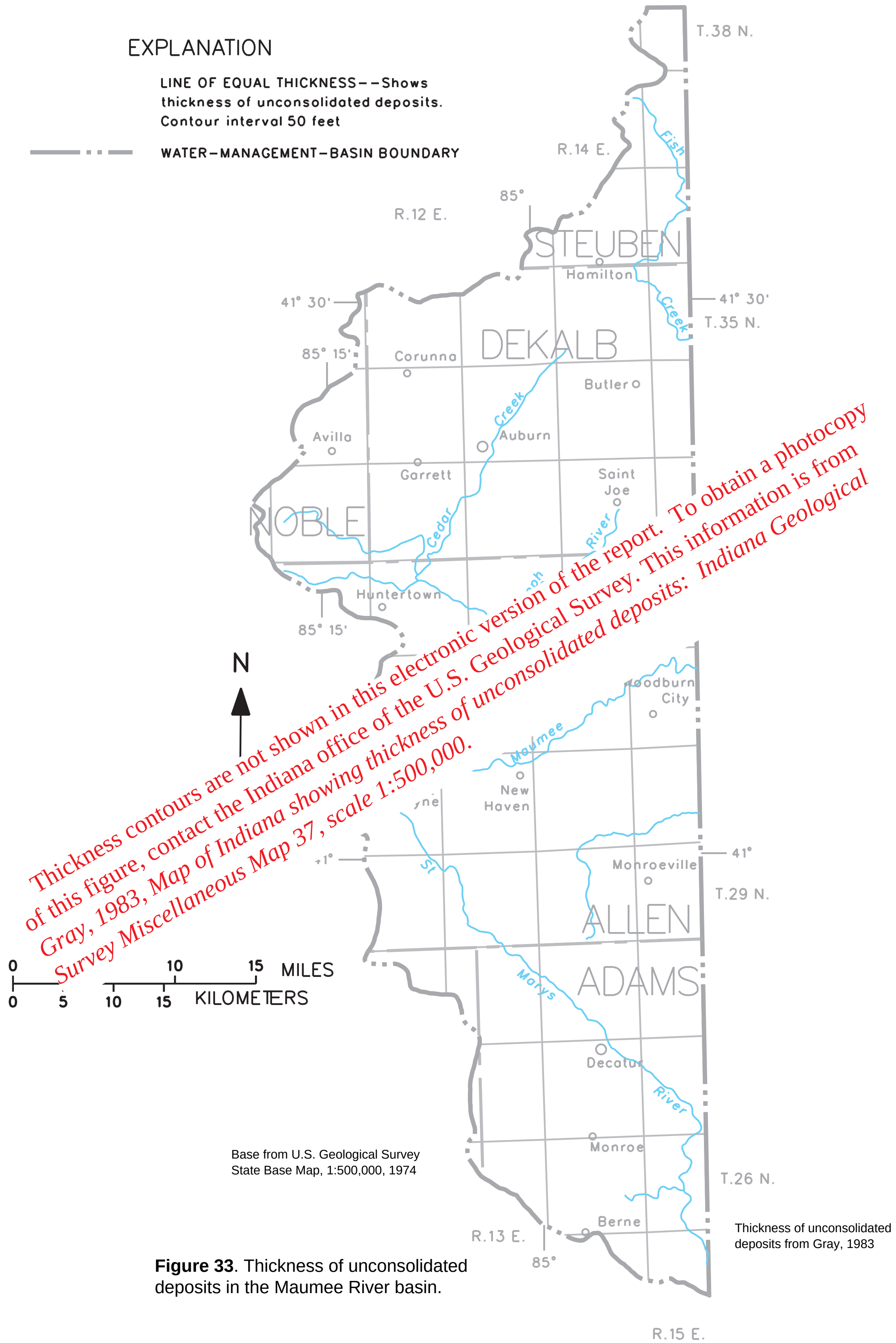


Figure 33. Thickness of unconsolidated deposits in the Maumee River basin.

large buried outwash-fan deposit (section 4C–4C′, fig. 34) is partially exhumed by Cedar Creek.

Few post-Wisconsinan deposits are found in the Maumee River basin. Some minor alluvial deposits, primarily composed of reworked outwash, are found in association with the Wisconsinan outwash deposits. Because the Maumee River formed after glaciation ended, none of the alluvial deposits along the Maumee River are reworked outwash. Minor deposits of muck, peat and marl, all of Holocene age, also are present in the basin.

Aquifer Types

Five hydrogeologic sections (sections 4A–4A′ to 4E–4E′, fig. 34) were produced for this atlas to depict aquifer types in the Maumee River basin. The hydrogeologic sections are oriented south-north, approximately perpendicular to the Maumee River, and are spaced 6 mi apart (fig. 30). The section lines produced from logs of 305 water-supply and test wells have a total length of 244 mi. The average density of logged wells plotted along the sections is 1.3 wells per mile, (approximately one well every 4,000 ft).

The map showing the extent of aquifers in the Maumee River basin (fig. 35) was constructed by use of the hydrogeologic sections. Additional information for the aquifer map was from the Quaternary geologic map of Indiana (Gray, 1989) and other publications referenced in this chapter.

The aquifer map shows the five aquifer types that are commonly used for water supply in the Maumee River basin. Of these aquifer types, four are restricted to the unconsolidated deposits. These include surficial sand and gravel aquifers, buried sand and gravel aquifers, discontinuous sand and gravel aquifers in isolated deposits, and sand and gravel in buried bedrock valleys. The only bedrock aquifer type used in this basin is carbonate bedrock of Silurian and Devonian age. Characteristics of the five aquifer types mapped in the Maumee River basin are summarized in table 6.

Unconsolidated Aquifers

Surficial Sand and Gravel Aquifers

Surficial sand and gravel aquifers have been deposited by present-day streams (alluvial) and by glacial meltwater (outwash). Alluvial deposits adjacent to the St. Marys and St. Joseph Rivers, and Cedar Creek (fig. 35) are generally thin and are not significant sources of ground water. Most present-day streams follow former glacial drainage channels and have reconfigured the glacial deposits. Because it does not follow a glacial drainage channel, the Maumee River has few alluvial deposits associated with it.

The bulk of the surficial sand and gravel aquifers in the Maumee River basin are composed of outwash. Most of the major streams draining the basin have outwash deposits adjacent to their channel (fig. 35). The outwash deposits in the basin are commonly 1/2 to 1 mi wide and as much as 40 ft thick (section 4B–4B′ and 4C–4C′, fig. 34). The Fort Wayne outlet to the Wabash-Erie Channel in southwestern Fort Wayne (fig. 7) and the Cedar Creek outlet to the Eel River near Huntertown have little or no outwash along their channels. These former outlet channels are located on divides, and streams no longer occupy them. Although the Fort Wayne outlet is up to 3 mi wide, only minor outwash deposits are present (section 4B–4B′, fig 34).

One additional type of surficial sand deposit in the Maumee River basin is beach sand. East of Fort Wayne, deposits of beach sand follow the former shoreline of ancient Lake Maumee. These sand deposits are at an altitude of about 760 to 775 ft, which corresponds to the altitude of the Fort Wayne outlet (sections 4D–4D′ and 4E–4E′, fig. 34). Beach ridge deposits are not on the aquifer map, because they generally are not productive aquifers in the Maumee River basin. Most unconsolidated sand and gravel aquifers were buried under clay-loam till during glacial disintegration.

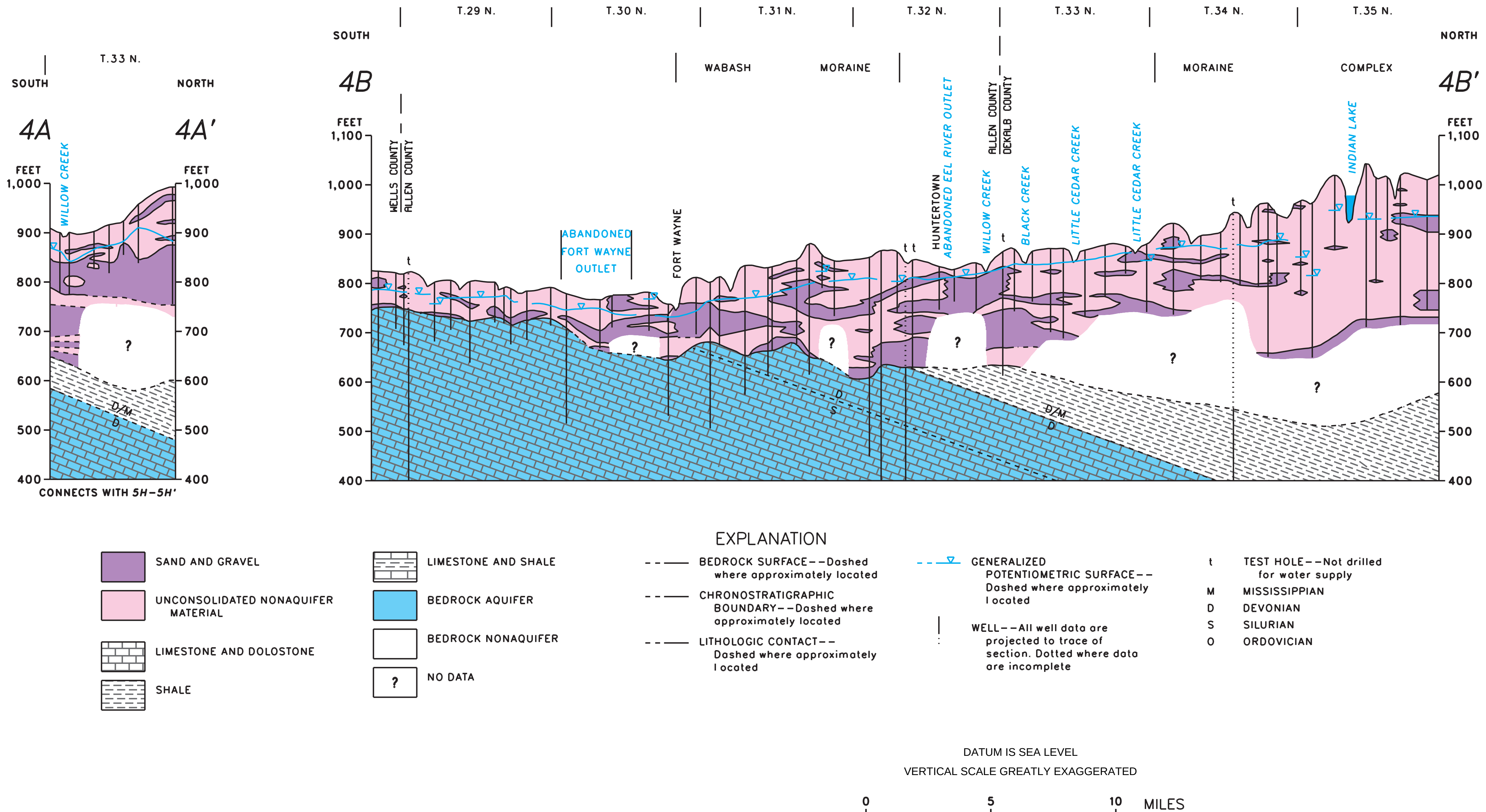
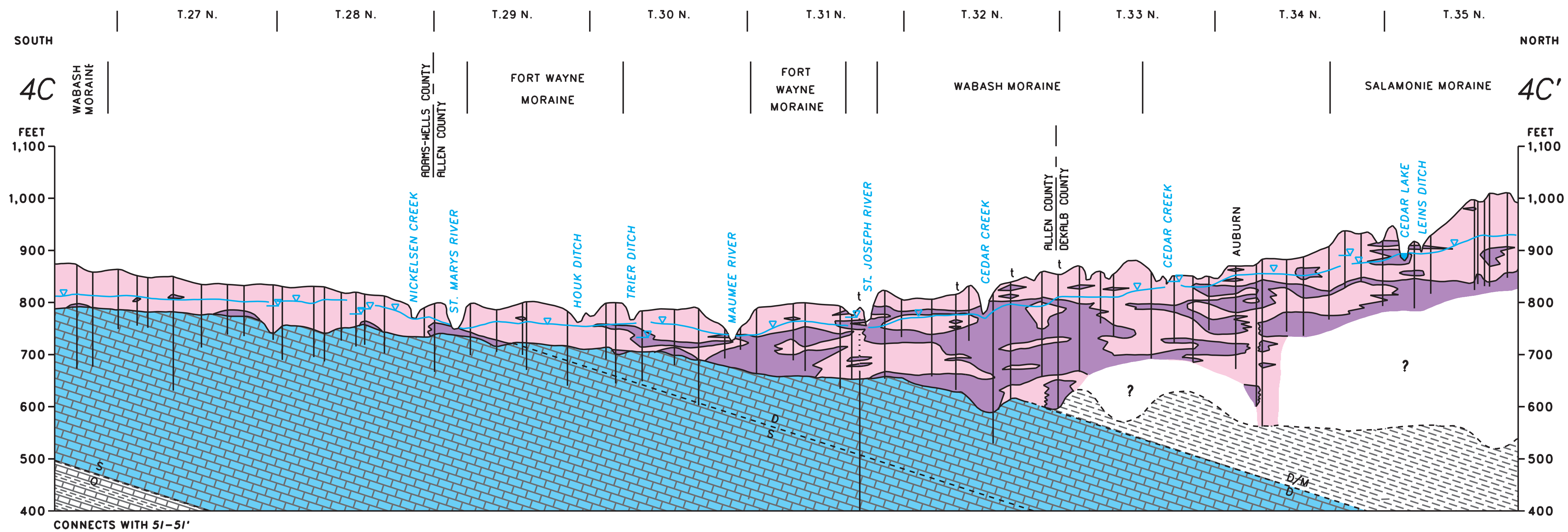


Figure 34. Hydrogeologic sections *4A–4A′* to *4E–4E′* of the Maumee River basin.



Buried Sand and Gravel Aquifers

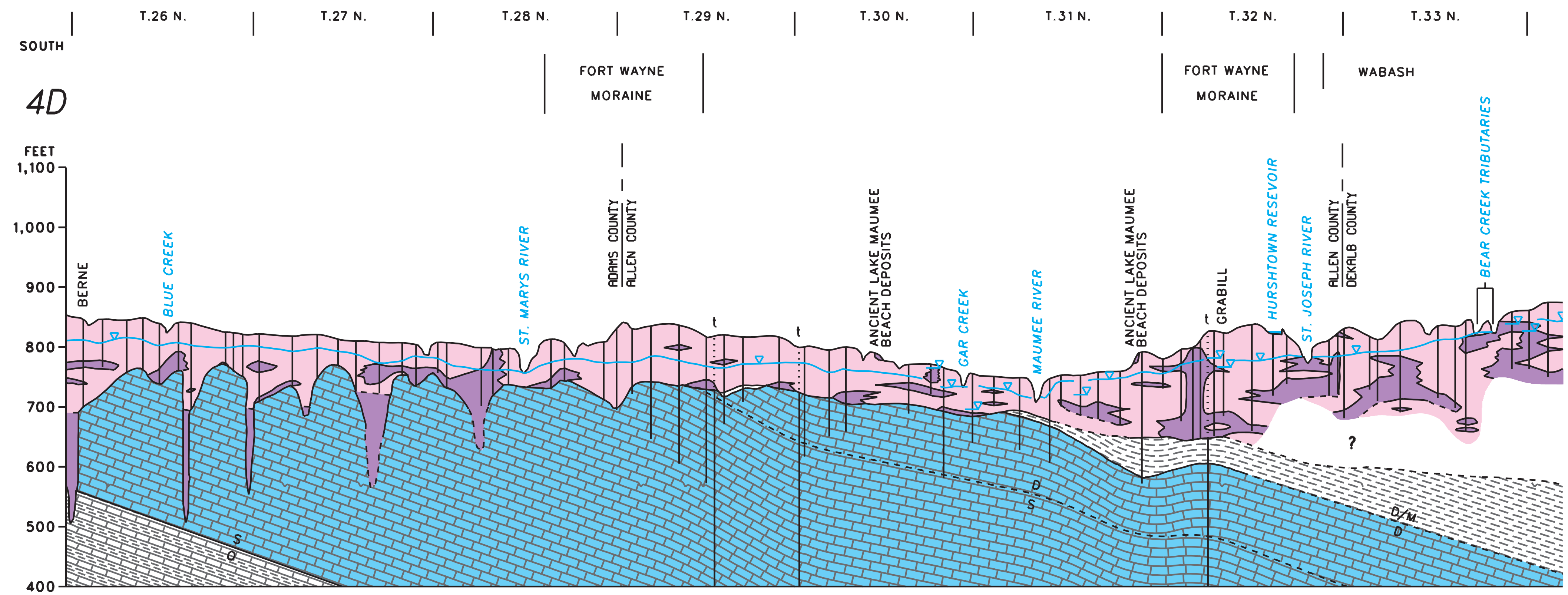
Buried sand and gravel aquifers (sections 4A–4A′ to 4E–4E′, fig. 34) are laterally continuous deposits that were formerly coalescing outwash fans, outwash plains, kame terraces and other ice-contact stratified deposits. Because these aquifers were not deposited uniformly, aquifer characteristics such as thickness, texture, and distribution are highly variable. Post depositional slumping of super saturated deposits, ice collapse, and erosion have caused additional disruption of these aquifer materials. The aquifer map (fig. 35) indicates areas where one or more of these buried aquifers is present.

Although most buried sand and gravel aquifers are not exposed by stream erosion, buried sand and gravel aquifers are exposed by Little Cedar Creek in T. 33 N. and by ditching on the north side of the abandoned Fort Wayne outlet in T. 30 N. (section 4B–4B′, fig. 34); by Cedar Creek in T. 32 N. and the St. Joseph River in T. 31 N. (section 4C–4C′, fig 34); by West Branch and a tributary to Fish Creek in T. 37 N. and by the Maumee River in T. 31 N. (section 4E–4E′, fig. 34). From the northeastern corner of Indiana south along section 4E–4E′ (fig. 34) to the Maumee River, the potentiometric surface of the buried sand and gravel aquifer slopes south at 7.8 ft/mi. This closely approximates the slope of the land surface.

Nearly all ground-water production north of the Maumee River is from buried sand and gravel aquifers (fig. 34). Although highly variable, the average thickness of buried aquifers in Allen County is 25 ft (Bleuer and Moore, 1978, p. 46). The median well yield from large diameter wells (10 in. or larger) that are finished in buried sand and gravel deposits in Allen County is 250 gal/min; well yields in this area range from 20 to 500 gal/min (Bleuer and Moore, 1978, p. 46). Water in buried sand and gravel aquifers is of suitable quality for drinking.

Clark (1980, p. 211) indicates two areas north of the St. Joseph River in Dekalb County where more than 1,000 gal/min of ground water is available from buried sand and gravel aquifers. Equally large yields are probably available throughout this part of the basin, as large yields have been found wherever ground-water exploration has been done. The highest yield noted from a well plotted on the Maumee River basin hydrogeologic sections is a well in T. 34 N., R. 14 E. (section 4E–4E′, fig. 34). This well is 24 in. in diameter and is 180 ft deep, and it was test pumped at 2,250 gal/min.

An extensive sand and gravel aquifer, a buried outwash fan of Saginaw Lobe association (A.J. Fleming, Indiana Geological Survey, oral commun., 1991), underlies a 110-mi^2 area in northwestern Allen County and southwest Dekalb County. Centered on Huntertown, this buried outwash fan slopes southeast into the Maumee River basin from the crest of a buried moraine. Portions of this buried fan are mapped in Tps. 32 and 33 N. (sections 4A–4A′, 4B–4B′, and 4C–4C′, fig. 34). Planert (1980, p. 52) found that 30 to 39 Mgal/d could be developed from the unconsolidated sand and gravel aquifers in northwestern Allen County; however, he also found that these ground-water withdrawals would decrease streamflow in the St. Joseph River at Fort Wayne by 32 to 38 ft^3/s.



DATUM IS SEA LEVEL

VERTICAL SCALE GREATLY EXAGGERATED

Figure 34. Hydrogeologic sections *4A–4A′* to *4E–4E′* of the Maumee River basin—Continued.

Discontinuous Sand and Gravel Aquifers

Discontinuous sand and gravel aquifers are similar to buried sand and gravel aquifers, except that they occur intermittently at one horizon or randomly dispersed throughout the drift. Some discontinuous buried sand and gravel was deposited in meandering channels. In the Maumee River basin, almost all discontinuous sand and gravel aquifers are south of the Maumee River. Drift in this area thins to less than 100 ft.

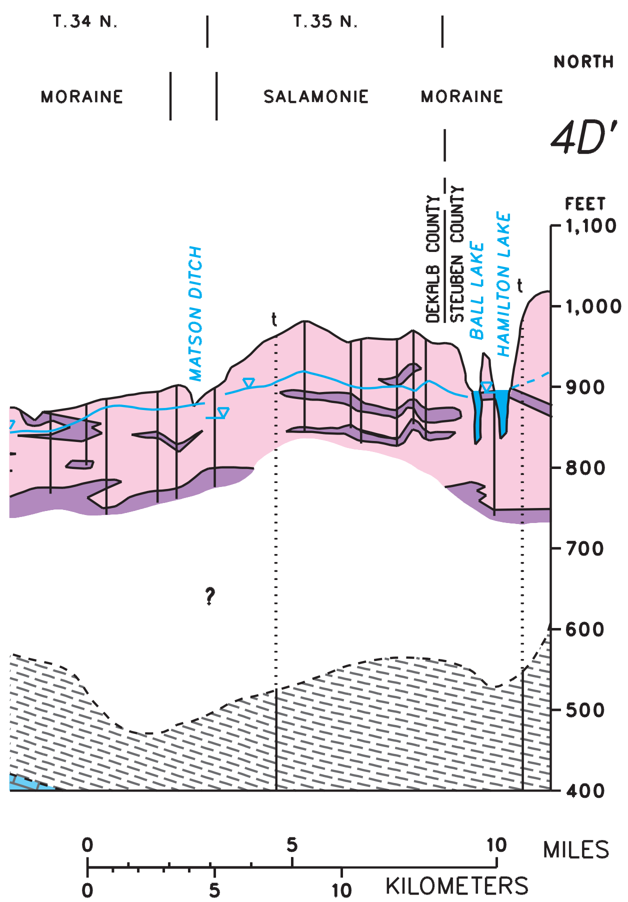
Discontinuous sand and gravel aquifers are rarely used for ground-water supply because of the abundance of fine sand, silt, and clay in the discontinuous aquifer and the availability of reliable ground-water supplies in the bedrock. Drillers commonly identify the discontinuous sand and gravel aquifer as “dirty gravel” in well logs. Yield from the discontinuous area south of the Maumee River is generally less than 20 gal/min. Few logs of wells drilled in this area report yields from the discontinuous aquifer, because drillers commonly finish the wells in the bedrock aquifer.

Sand and Gravel Aquifer in Buried Bedrock Valleys

A deep, preglacial bedrock valley underlies the drift in the southern tip of the Maumee River basin. This buried valley is known as the St. Marys Bend Segment of the Marion Valley Section of the Lafayette Bedrock Valley System (fig. 7) (Bleuer, 1989, p. 5), and was formerly known as the Teays Valley. Before burial, the Marion Valley Section had limestone cliffs that were 300 ft high. During the Pleistocene glacial period, this valley system filled with glacial and lake sediments. Most valley fill deposits in the basin are clay, although several sand and gravel zones are present. Some of the gravels are quite coarse (Bleuer and others, 1991, p. 86). High yields from these deposits are due to the coarseness of the aquifer, depth of burial, and the correspondingly large drawdowns available.

Bleuer (1991, fig. 6D, p. 63) indicates that there are three aquifer horizons in this part of the St. Marys Bend Segment. The upper aquifer is heavily used; the middle aquifer is fine grained sand and does not produce large volumes of water; the lowest aquifer is a coarse sand and gravel, which has the potential for the largest ground-water production.

The city of Decatur, Adams County, constructed its well field in the St. Marys Bend Segment of the Lafayette Bedrock Valley. This well field is near Berne, 12 mi south of Decatur, near the divide between the Maumee River basin and the Upper Wabash River basin. The well field pumps water from the upper aquifer. This aquifer is a 40-foot-thick, coarse-grained, cobbly sand and gravel deposit confined under 110 ft of clay. Well yields from this well field range from 1,000 to 1,400 gal/min with approximately 40 ft of drawdown (Bleuer and others, 1991, p 86).



Bedrock Aquifers

Carbonate Bedrock Aquifer

The carbonate bedrock aquifer underlies the entire Maumee River basin (sections 4A–4A′ to 4E–4E′, fig. 34), with the exception of the small area underlain by the Lafayette Bedrock Valley (section 4E–4E′, fig. 34) where carbonate rock has been eroded. In northern Allen, Dekalb, Noble and Steuben Counties, the bedrock dip and drift thickness restrict the use of the carbonate bedrock aquifer (fig. 35). The Silurian-Devonian carbonate bedrock aquifer is used predominately south of the Maumee River. The carbonate bedrock aquifer is below the water table throughout the Maumee River basin and is confined except where stone quarries dewater it for mining.

The median yield from large-diameter wells completed in the carbonate bedrock aquifer in Allen County is 175 gal/min; well yields range from 35 to 500 gal/min (Bleuer and Moore, 1978, p. 46). South of the Maumee River, the thickness of the drift overlying the carbonate bedrock aquifer averages about 100 ft, and most wells are completed in the bedrock. South of the Maumee River, the potentiometric slope in the carbonate bedrock aquifer slopes north at 3.7 ft/mi. The slope of the potentiometric surface closely approximates the land surface.

Karst development in this carbonate bedrock was extensive at the beginning of the Quaternary period. This secondary enhancement of bedrock permeability is responsible for the large well yields available from the carbonate bedrock aquifer. Planert (1980, p. 15) found the permeability of the carbonate bedrock aquifer in Allen County is greatest near the preglacial erosion surface and decreases with depth. The full carbonate bedrock aquifer sequence is about 700 ft thick. The smallest yields from the carbonate bedrock aquifer are found in the shallow bedrock areas south of the Maumee River and north of the St. Marys River. Northeast of Monroeville, in T. 30 N., R. 15 E., the maximum potential ground-water yield from the bedrock is 50 gal/min (Clark, 1980, p. 211).

The Maumee River is the lowest surface-water outlet draining the north-dipping part of the carbonate bedrock aquifer sequence in Indiana. Some of the ground-water flow in the carbonate bedrock aquifer sequence enters the Maumee River basin along the southwest boundary of the Maumee River basin. Greeman (1991) found that both the White River basin, and the Wabash River basin (fig. 1) contribute water to the ground-water flow in the carbonate bedrock aquifer.

The decision to complete a well in the carbonate bedrock aquifer can be based on absence of an adequate unconsolidated aquifer, problems associated with having to set a well screen in an unconsolidated aquifer, or water-quality considerations. The quality of water differs between the bedrock and unconsolidated aquifers. Locally, the carbonate rocks contain abundant gypsum ($CaSO_4$), which is the major source of sulfate. Sulfate is a common ground water constituent that can occur at undesirable high concentrations. Bleuer and Moore (1978, p. 43) report that, in Allen County, water from the carbonate bedrock aquifer has significantly higher concentrations of dissolved strontium and sodium and significantly lower concentrations of dissolved bicarbonate, iron, and zinc than water from unconsolidated aquifers. None of these constituents present a health hazard in the concentrations reported.

Ordovician rocks form a confining unit underlying the Silurian-Devonian carbonate bedrock aquifer throughout the Maumee River basin. Similarly, till functions as a confining unit overlying the Silurian-Devonian carbonate bedrock aquifer. Because of these confining units, ground-water flow in the carbonate bedrock aquifer is isolated; long flow paths and a slow transmission rate cause ground water to remain in the carbonate bedrock aquifer for years. During the long transit, ground water can become heavily mineralized. Within the Maumee River basin, heavily mineralized water from the carbonate bedrock has been found south of the Maumee River. However, water in the Silurian-Devonian carbonate bedrock aquifer is substantially less mineralized than water in the more deeply buried Cambrian and Ordovician bedrock aquifers.

Summary

The Maumee River basin encompasses 1,283 mi^2 of northeastern Indiana and includes large parts of Adams, Allen, and Dekalb Counties and parts of Noble and Steuben Counties. The physiography of the area can be divided into three major regions: the Steuben Morainal Lake Area, the Lake Maumee Lacustrine Plain, and the Tipton Till Plain. Topography ranges from nearly level in the Maumee Lacustrine Plain to hilly (more than 200 ft of relief) in the Steuben Morainal Lake Area.

Moraines divide the Maumee River basin into four subbasins that are drained by the Maumee River, the St. Marys River, the St. Joseph River, and Cedar Creek. The St. Marys River and the St. Joseph River converge at Fort Wayne to form the Maumee River. Surface-water drainage in the Maumee River basin is part of the St. Lawrence River system.

Bedrock underlying the glacial drift ranges from Late Ordovician to Early Mississippian in age. Silurian and Devonian carbonate bedrock, less than 300 ft deep, underlies the southern half of the basin. The Silurian-Devonian carbonate sequence ranges from 0 to 700 ft in thickness. The carbonate bedrock sequence is absent at the base of the St. Marys Bend segment of the preglacial Lafayette Bedrock Valley. Younger shales overlie the carbonate bedrock sequence in the northern half of the basin. All surface sediments are glacial or fluvial in origin. Glacial drift covers most of the bedrock, and depths range from 0 to about 450 ft. All areas where drift thickness is less than 50 ft are south of the Maumee River.

Five aquifer types are commonly used for water supply in the Maumee River basin. Surficial sand and gravel aquifers are found along most of the major streams in the basin. Both buried and discontinuous sand and gravel aquifers are present in the Maumee River basin. Buried aquifers are used north of the Maumee River whereas discontinuous aquifers may be used south of the Maumee River. Adequate domestic supplies are available from both types of aquifers, although large yields are available only from buried aquifers. Large yields are available from sand and gravel aquifers in the St. Marys Bend Segment of the Lafayette Bedrock Valley in the southern tip of the Maumee River basin. The carbonate bedrock aquifer underlies the southern half of the basin, and is a productive source of ground water.

Ground water is readily available throughout the basin. Large yields of ground water are available from the unconsolidated aquifers in northern Allen County and southern Dekalb County. Yields of 200 gal/min or more are available from unconsolidated aquifers north of the Maumee River. Yields of 35 gal/min or more are available from the carbonate bedrock aquifer south of the Maumee River.

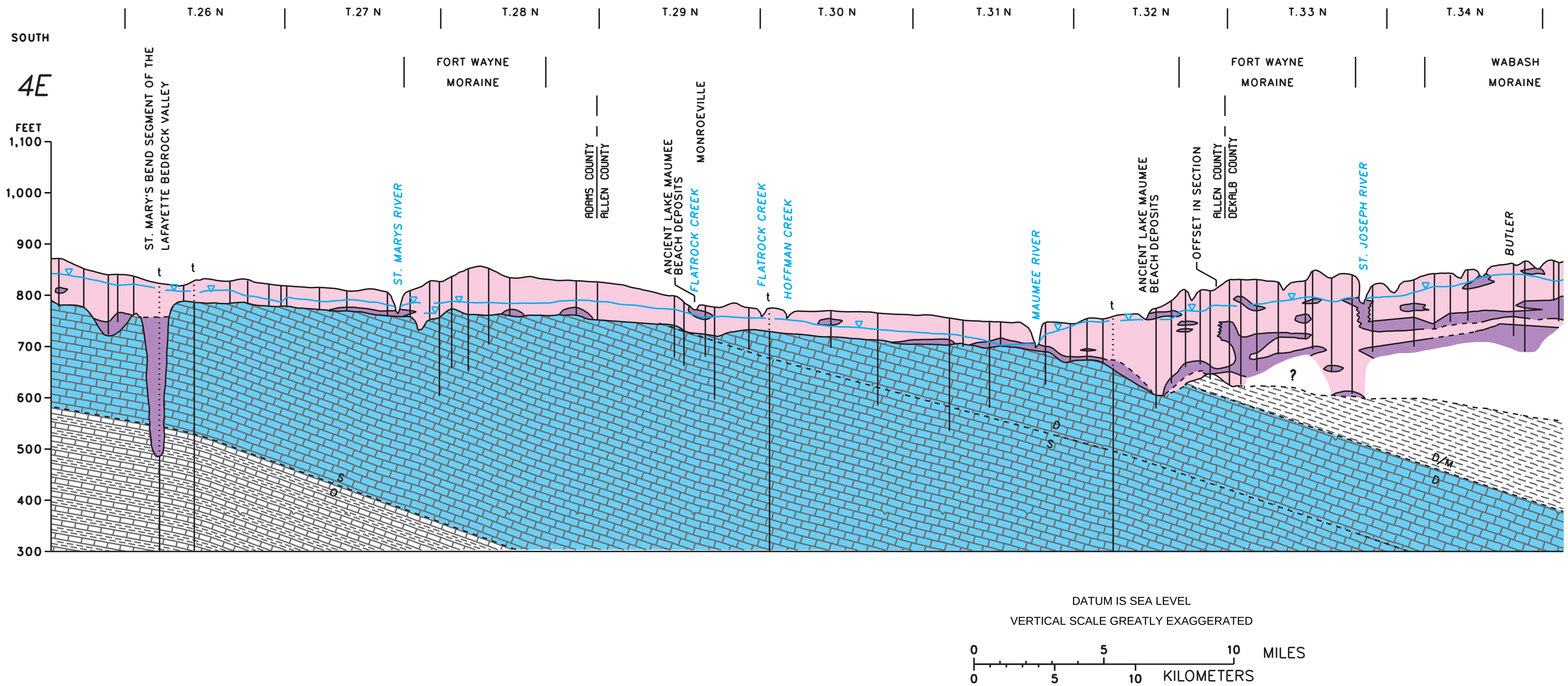


Figure 34. Hydrogeologic sections *4A–4A′* to *4E–4E′* of the Maumee River basin—Continued.

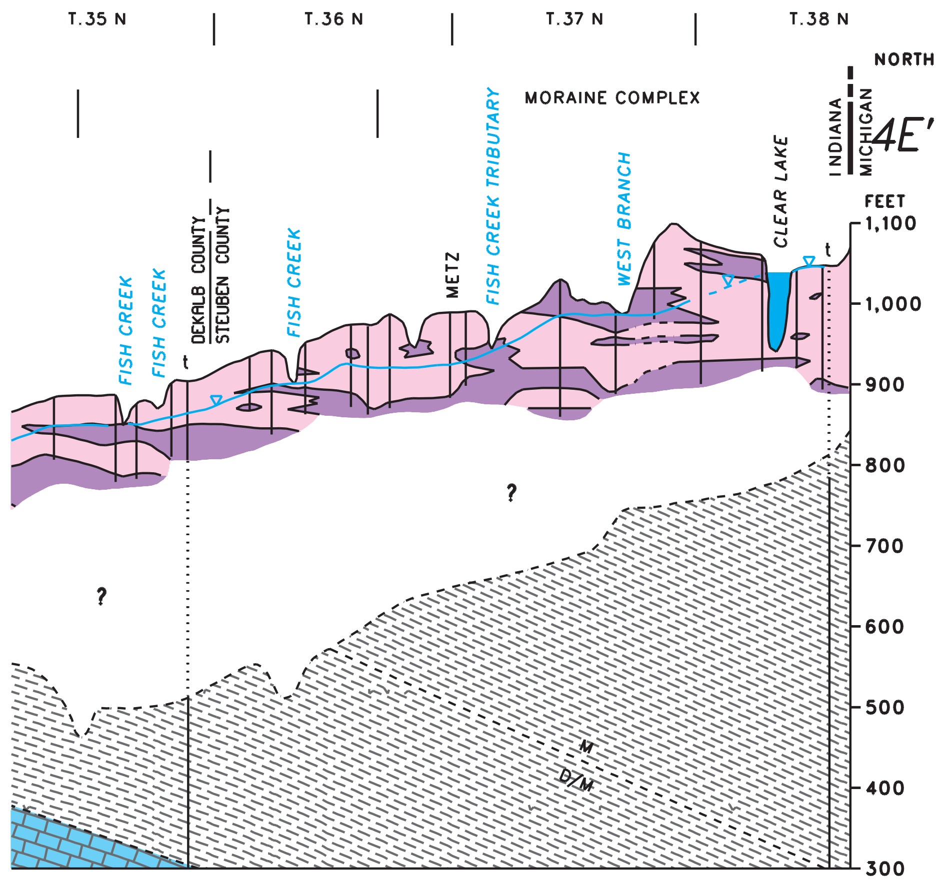


Table 6. Characteristics of aquifer types in the Maumee River basin

[≥ , greater than or equal; locations of aquifer types shown in fig. 35]

Aquifer type	Thickness (feet)	Range of yield (gallons per minute)	Common name(s)
Surficial sand and gravel	0- 40	No data	
Buried sand and gravel	0- 150	20- 2,250	Intertill sand and gravel
Discontinuous sand and gravel	0- 80	≥20	
Sand and gravel in buried bedrock valley	0- 50	No data	Lafayette Bedrock Valley aquifer[1]
Carbonate bedrock	0- 700	35- 500	Silurian-Devonian carbonate aquifer

[1]Bleuer and others, 1991.

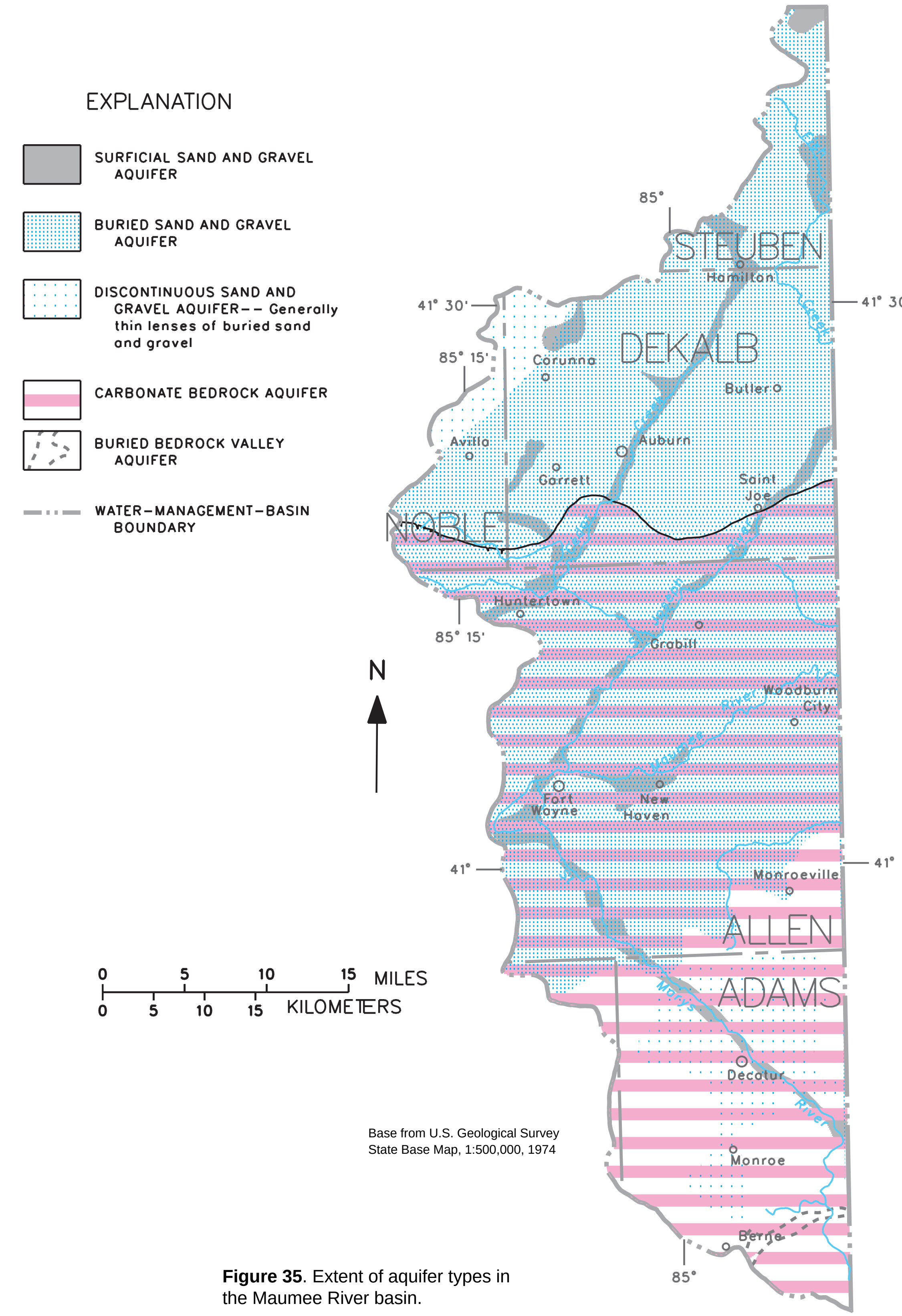


Figure 35. Extent of aquifer types in the Maumee River basin.

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